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WILDFIRE AND MAMS DATA FROM STORMFEST

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Space Science Laboratory
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Early in 1992, NASA participated in an inter-agency field program called STORMFEST. The STORM-Fronts Experiment Systems Test (STORMFEST) was designed to test various systems critical to the success of STORM I in a very focused experiment. The field effort focused on winter storms in order to investigate the structure and evolution of fronts and associated mesoscale phenomena in the central United States. This document describes the data collected from two instruments onboard a NASA ER2 aircraft which was deployed out of Ellington Field in Houston, Texas from February 13 through March 15, 1992, in support of this experiment. The two instruments were the Wildfire (a.k.a. the MODIS-N Airborne Simulator, MAS) and the Multispectral Atmospheric Mapping Sensor (MAMS).

14. SUBJECT TERMS
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LIST OF ACRONYMS

AVHRR	Advance Very High Resolution Radiometer
HIRS	High-resolution Infrared Radiometer Sounder
MAMS	Multispectral Atmospheric Mapping Sensor
MAS	MODIS-N Airborne Simulator
McIDAS	Man-computer Interactive Data Acquisition System
MODIS-N	MODerate-resolution Imaging Spectrometer - Nadir
MSFC	Marshall Space Flight Center
NASA	National Aeronautics and Space Administration
NCAR	National Center for Atmospheric Research
NEΔT	Noise Equivalent Delta Temperature
QVS	Quick View System
STORMFEST	STORM-Fronts Experiment Systems Test
TM	Thematic Mapper
TOMS	Total Ozone Mapping Sensor
VAS	VISSR Atmospheric Sounder
VISSR	Visible Infrared Spin Scan Radiometer

TECHNICAL MEMORANDUM

WILDFIRE AND MAMS DATA FROM STORMFEST

I. INTRODUCTION

Early in 1992, NASA participated in an inter-agency field program called STORMFEST. The STORM-Fronts Experiment Systems Test (STORMFEST) was designed to test various systems critical to the success of STORM I in a very focused experiment (NCAR, 1992). This effort focused on winter storms in order to investigate the structure and evolution of fronts and associated mesoscale phenomena in the central United States. The field phase, conducted from February 1 through March 15, 1992, was composed of three closely related components: (1) investigations of the structure and evolution of fronts and mesoscale features with an emphasis on precipitation and severe weather, (2) an assessment of the capability of the new operational and research meteorological instruments and observing networks, and (3) a study of mesoscale predictive capabilities and limitations.

NASA's role in STORMFEST was one of collecting aircraft remote sensing measurements during the field phase of the program and to participate in research supporting the use of these measurements to address specific STORMFEST objectives. The ER2 high-altitude platform was used with a suite of advanced visible, infrared, and microwave instruments to measure temperature, humidity, ozone, precipitation, and atmospheric electric fields. These measurements were to demonstrate prototype observing capabilities and to study the structure and dynamics of winter storms and mesoscale events. The discussion below highlights two of the six instruments flown on the ER2, namely, the Wildfire spectrometer and the Multispectral Atmospheric Mapping Sensor (MAMS).

II. DATA COLLECTION OBJECTIVES

The Wildfire and MAMS spectrometers were used during the STORMFEST field program to support two general research topics which are funded by NASA Headquarters: (1) investigate the variability of upper tropospheric/lower stratospheric ozone and (2) study the structure and dynamics of jet streaks and associated gravity waves.

A. Wildfire

The newly developed Wildfire spectrometer[1] (Daedalus Enterprises, Inc., under a NASA Ames Research Center SBIR) was flown aboard the NASA ER2 to collect a variety of unique high-resolution measurements in support of STORMFEST. This work focuses on the feasibility of using passive infrared techniques to detect small-scale variations in the ozone distribution important to the study of jet streaks and mid-latitude storm systems. The specific goals are to:

(1) collect high quality Wildfire data in conjunction with other in situ and remote measurements available during the STORMFEST field phase (February 1 - March 15, 1992)

(2) develop algorithms for retrieval of the ozone variability below the flight altitude, compare and integrate the results with total column ozone from TOMS and HIRS

(3) use the ozone information, along with water vapor imagery, to better understand the three-dimensional structure and dynamics of jet streaks and frontal systems in a case study investigation.

The first objective was successfully completed during the field phase of this study. A high quality data set now exists and will be used to address the latter two objectives.

The relationship of characteristic features in the ozone distribution to nearby frontal systems and jet streaks has received increased attention during the last decade, largely because global maps of total ozone have become available on a regular basis from space. Comparisons of the TOMS measurements with available meteorological analyses have suggested various conceptual models that link the ozone patterns to possible kinematic distur-

[1]a.k.a., the MODIS-N Airborne Simulator, MAS

bances in the upper troposphere and lower stratosphere. But considerable supposition has been incorporated in these three-dimensional models, because TOMS provides no information about the vertical locations where the changes in ozone concentration occur, and suitable concurrent in situ data typically have been unavailable. Large values of total ozone have frequently been observed to coincide with frontal zone tropopause folds, where a wedge of dry, ozone-rich stratospheric air intrudes sharply downward into the troposphere (Shapiro *et al.*, 1982; Uccellini and Keyser, 1985). The increased ozone amounts would be consistent with a simple deepening of the stratospheric ozone column. However, Sechrist *et al.* (1986) and Chesters *et al.* (1990) both found TOMS ozone maxima that were displaced some 300-500 km eastward of the fold in several cases. Both discussed possible circulation patterns in the lower or middle stratosphere that might be responsible, but the lack of information about the vertical ozone structure prevented more definitive conclusions from being drawn.

The NASA ER2 aircraft flew at an altitude of 20 km during STORMFEST, slightly below the climatological ozone maximum, yet far above the tropopause. The opportunity to fly the Wildfire instrument at that altitude over active frontal disturbances to observe ozone and water vapor at high resolutions will prove to be very instructive. By comparing the Wildfire products to TOMS- and/or HIRS-derived total ozone estimates, two layers of ozone information can be defined (above and below 20 km), which will help to resolve the questions raised by previous case studies. Obtaining these measurements within the data-rich context of STORMFEST is especially valuable in refining our understanding of frontal zone and jet streak dynamics, and how they contribute to the total ozone signatures being observed from satellite orbit. Although the usual derivation of total ozone content uses measurements in the ultraviolet portion of the spectrum, the use of infrared measurements to estimate total column ozone is not new (e.g., Lienesch, 1988; Chesters and Neuendorffer, 1990). The Wildfire spectrometer presents an opportunity to apply several new techniques to the infrared retrieval problem.

B. Multispectral Atmospheric Mapping Sensor (MAMS)

The main science objective with MAMS for STORMFEST is the detection and diagnostic analysis of water vapor and cloud signatures related to gravity waves. Gravity waves are often generated by intense convective activity or by the propagation of an unbalanced jet streak through an upper-level trough. The analysis of the observable parameters of these wave features is important to understanding their initiation and role in the dynamics of mid-latitude weather systems. To achieve this objective, the ER2 made several flights over intense storm systems. An additional flight was made over the exit region of a rapidly propagating jet streak. Data collected from MAMS will be used to identify any discernible gravity wave features present in cloud tops or water vapor imagery ahead of significant storm features. The MAMS data will be used to characterize the structure of these features, determine propagation rates, and to derive relative and absolute moisture parameters associated with these features. These parameters will allow for a quantitative analysis of the moisture variability associated with these features.

The upper tropospheric water vapor imagery from VAS is very useful in the study of upper-level dynamics of mid-latitude weather systems. This is readily apparent in video "loops" of this satellite channel which show smooth flowing patterns associated with large-scale weather disturbances. Changes in the brightness of the water vapor features are related to the vertical distribution of water vapor in the middle and upper troposphere, the integrated water vapor amount, and to a lesser degree the temperature profile. In addition, water vapor imagery can be used to discern small-scale variability of high clouds (particularly cirrus) and clear air atmospheric water vapor fields. In particular, MAMS water vapor imagery has been used to map clear air moisture variations in a number of different applications including lee wave situations (Jedlovec, 1984; Jedlovec, *et al.*, 1986b; Jedlovec, 1987).

III. AIRCRAFT INSTRUMENTATION

A. Wildfire (a.k.a., the MODIS-N Airborne Simulator, MAS)

The Wildfire spectrometer is a 50 channel airborne scanner that senses reflected and upwelling radiation from the Earth and atmosphere in fairly narrow, uniformly spaced regions of the near-infrared and thermal infrared spectrum (from 0.70 to 12.7 micrometers)[2]. The Wildfire was flown on a NASA ER2 high altitude aircraft at a nominal altitude of 20 km during STORMFEST, providing a horizontal ground resolution of each field-of-view of about 50 m at nadir. From this altitude, the width of the entire cross path field-of-view scanned by the sensor is roughly 37 km, thereby providing detailed resolution of atmospheric and surface features across the swath width and along the aircraft flight track. The Wildfire design is based on that of other instruments developed by Daedalus Enterprises, Inc. for visible and infrared mapping. It shares the same scan head, digitizer, tape system, and supporting electronics as other airborne scanners for the ER2, including the MAMS. The difference in airborne scanners lies in the different spectrometers and therefore provide different spectral capabilities. The Wildfire channels used during STORMFEST are presented in Table 1. The primary channels of interest are the thermal infrared channels (8-12). These channels have varying sensitivity to water vapor and ozone absorption and will be used to retrieve total ozone content in a column of the atmosphere below the aircraft. The horizontal distribution of this parameter will provide the basis for the case study analysis. The visible channels will serve to identify surface and cloud features of interest. The mid-infrared channels became unusable because of a leak which developed in the dewar. Channel 1 is used as a bit bucket for the least significant bits (9 and 10) of the 10 bit digitized data of channels 9-12 (Jedlovec *et al.,* 1989).

[2] The Wildfire spectrometer was in a state of development during 1991-1992, during which the spectral bands were constantly being changed. The Wildfire configuration presented here describes the state of the instrument during the October 1991 - February 1992 period. Details of the configuration after the STORMFEST flights can be obtained from Ken Brown at NASA Goddard Space Flight Center.

TABLE 1. SELECTED WILDFIRE CHANNELS FOR STORMFEST

Channel	Wavelength μm	Absorbing Constituents/Use
1	-	Bit bucket for ch 9-12 least significant bits
2	0.68	Broad band visible-near infrared
3	1.64	Reflective infrared
4	1.98	Reflective infrared
5	3.75	Bad dewar, no data
6	4.54	Bad dewar, no data
7	4.70	Bad dewar, no data
8	9.20	Ozone absorption (weak)
9	10.00	Ozone absorption (weak)
10	9.60	Ozone absorption (strong)
11	10.95	Clean window
12	12.45	Water vapor (weak)

B. Multispectral Atmospheric Mapping Sensor (MAMS)

The MAMS is a multispectral scanner which measures reflected radiation from the Earth's surface and clouds in eight visible/near-infrared bands, and thermal emission from the earth's surface, clouds, and atmospheric constituents (primarily water vapor) in four infrared bands (see Table 2). The MAMS was flown on the same NASA ER2 high-altitude aircraft as the Wildfire but not at the same time. The larger aperture of MAMS produced a single field-of-view resolution of 100 m at nadir. The width of the entire cross path field-of-view scanned by the sensor is still 37 km, thereby providing detailed resolution of atmospheric and surface features across the swath width and along the aircraft flight track. Further details about the MAMS may be found in Jedlovec *et al.* (1986a, 1989).

The infrared channels from MAMS are similar to those from the AVHRR and VAS sensors on existing weather satellites. The 11 μm channels of MAMS and VAS are very similar while that of the AVHRR is narrower and shifted toward shorter wavelengths. The 12 μm channel of AVHRR is positioned near 11.8 μm with a band width about twice that of MAMS and VAS (which are centered at longer wavelengths). The 12 μm channels measure upwelling radiation where water vapor and other constituent absorption (particularly by the Q-branch of CO_2 at 792 cm^{-1}) is more significant. The spectral differences of the 12 μm channels produce small differences in brightness temperatures for VAS and MAMS, but somewhat larger differences between AVHRR and MAMS (or VAS).

For STORMFEST, the 6.5 μm channel was used in place of the 3.7 μm channel to support the water vapor mapping and gravity wave activity. The MAMS re-router card was used to provide channels 9-12 at 10 bit resolution, with the least significant bits going in place of channel 1. When the 10 bit data are reconstructed, the two least significant bits will provide additional sensitivity to small amplitude variations in the scene data.

TABLE 2. MAMS CHANNELS FOR STORMFEST

Visible		Infrared		
Channel	Wavelength μm	Channel	Central Wavelength μm	Bandwidth @50% Response μm
1	0.42 - 0.45	9	6.54	6.28 - 6.98[b]
2	0.45 - 0.52[a]	10	6.54	6.28 - 6.98[b]
3	0.52 - 0.60[a]	11	11.12	10.55 - 12.24
4	0.60 - 0.67	12	12.56	12.32 - 12.71
5	0.63 - 0.73[a]			
6	0.69 - 0.83			
7	0.76 - 0.99[a]			
8	0.83 - 1.05			

[a] Similar to Landsat TM channel.

[b] Different channel gain and offsets.

IV. DATA FOR STORMFEST

A. ER2 Flights

The NASA ER2 aircraft flew in support of the STORMFEST field program from February 13 through March 15, 1992. The plane was deployed out of Ellington Field, just south of Houston, Texas. A total of 11 flights were made during the deployment, 8 of which directly supported the STORMFEST objectives. Table 3 lists all the ER2 STORMFEST flights, including the Wildfire/MAMS flights. Figure 1 shows the precise location of the aircraft flight tracks during the specific missions. The flight numbers and times are included in the legend of each map in Figure 1. Two of the flights with the Wildfire spectrometer (February 14 and 17) were in direct support of the ozone variability objectives. The Wildfire spectrometer was also flown on three other supporting missions. Six missions were flown with the MAMS; one (March 11) was in direct support of the gravity wave objectives.

B. Data Quality

The utility of a data set to meet a specific science objective is heavily dependent on data quality and whether the data set captured the phenomenon of interest. Instrument data quality is a function of a number of factors including instrument noise (both random and systematic), quality of the calibration data (directly affects relative and absolute calibration accuracy), appropriateness of channel gain/offset settings (affects channel sensitivity and dynamic range), the amount of missing data, and other data peculiarities. In general, the Wildfire data are of good quality and the MAMS data are very good. Information supporting these conclusions is presented below.

TABLE 3. WILDFIRE AND MAMS FLIGHTS FOR STORMFEST

Flight	Date	Number	Region	Instrument	Objective
1.	Feb.14 92045	92061	OK,KS,MO,AR,TX	Wildfire	Ozone variability tropopause fold
2.	Feb.17 92048	92062	OK,MO,AR,TX,TN	Wildfire	Ozone variability tropopause fold
3.	Feb.21 92052	92063	Gulf Coast, FL	Wildfire	Support thunderstorm flight
4.	Feb.23 92054	92064	CO, KS, TX	Wildfire	Support precipitation study
5.	Feb.25 92056	92065	NE,KS,OK,TX	Wildfire	Support HIS moisture mission
6.	Mar. 1 92061	92066	NE,KS,OK,TX	MAMS	Support HIS boundary layer study
7.	Mar. 7 92067	92067	TX, Gulf Coast	MAMS	ER2 test flight
8.	Mar. 8 92068	92068	TX	MAMS	Flight abort, AC problems
9.	Mar.11 92071	92069	TX,AR,MO,NE,KS	MAMS	Gravity waves, with MTS
10.	Mar.13 92073	92070	TX,LA, Gulf Coast	MAMS	MTS system test
11.	Mar.14 92074	92071	TX,OK,NE,KS	MAMS	HIS 4-D assimilation study

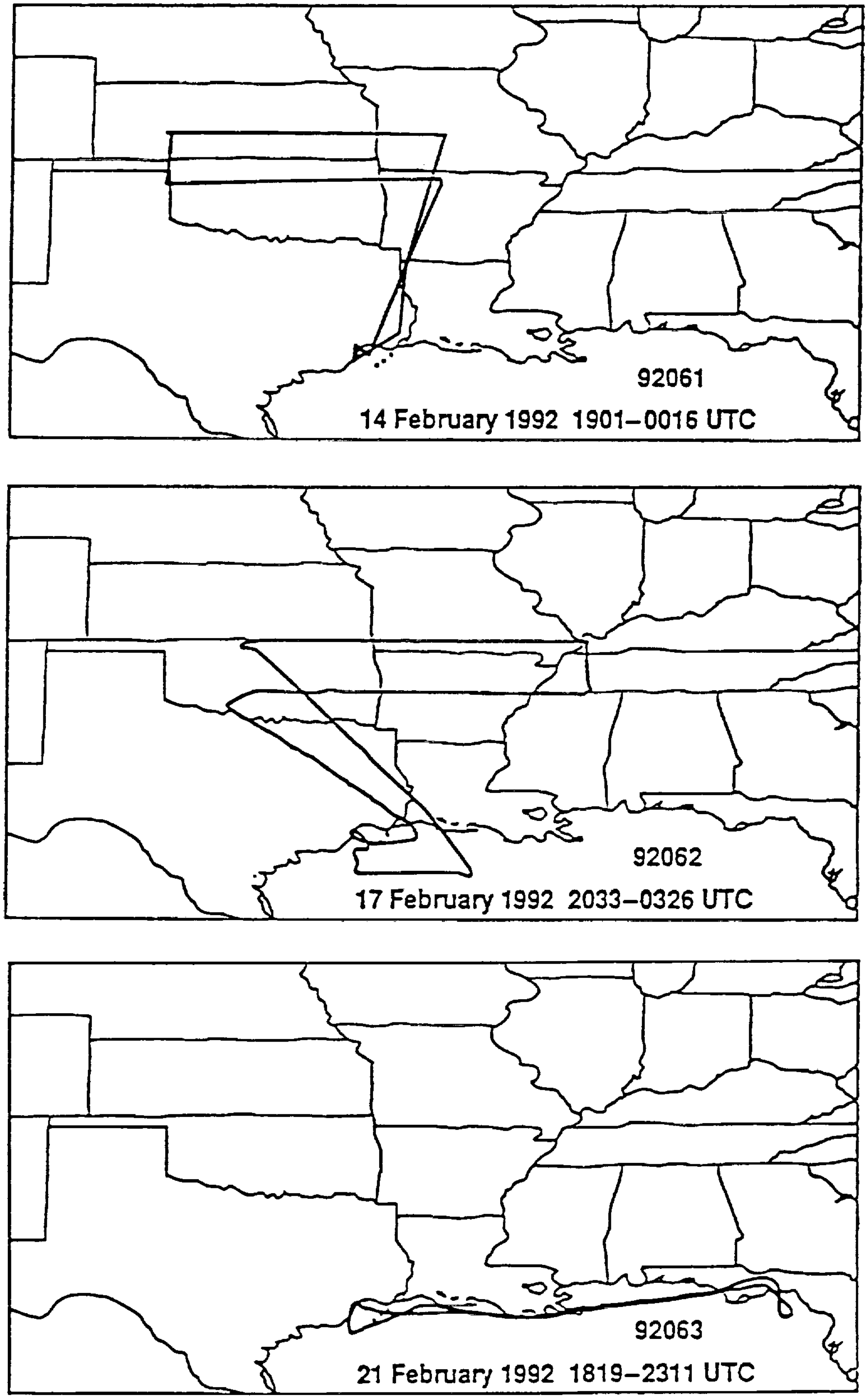

Figure 1. Flight track maps for the eleven ER2 flights during STORMFEST.

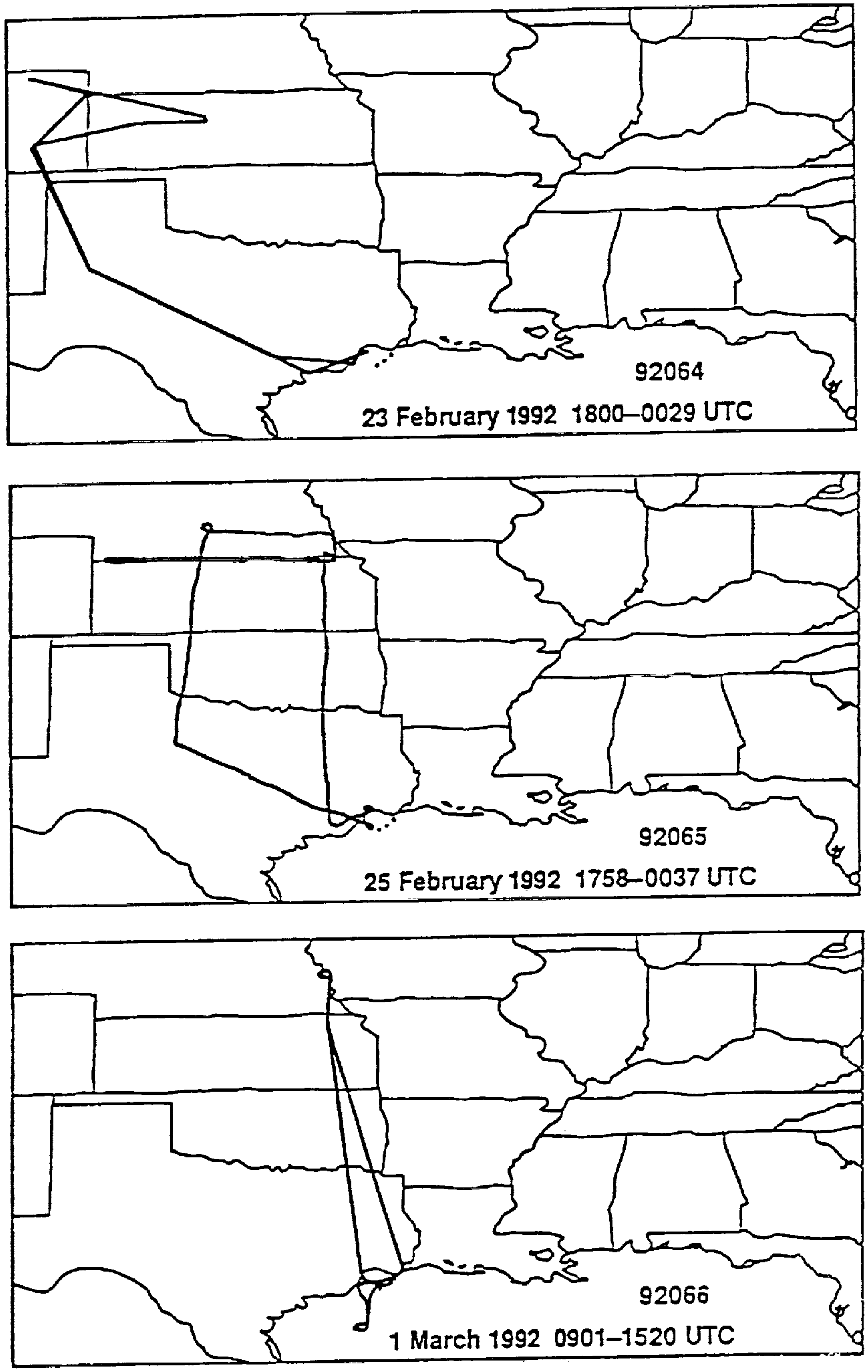

Figure 1. continued

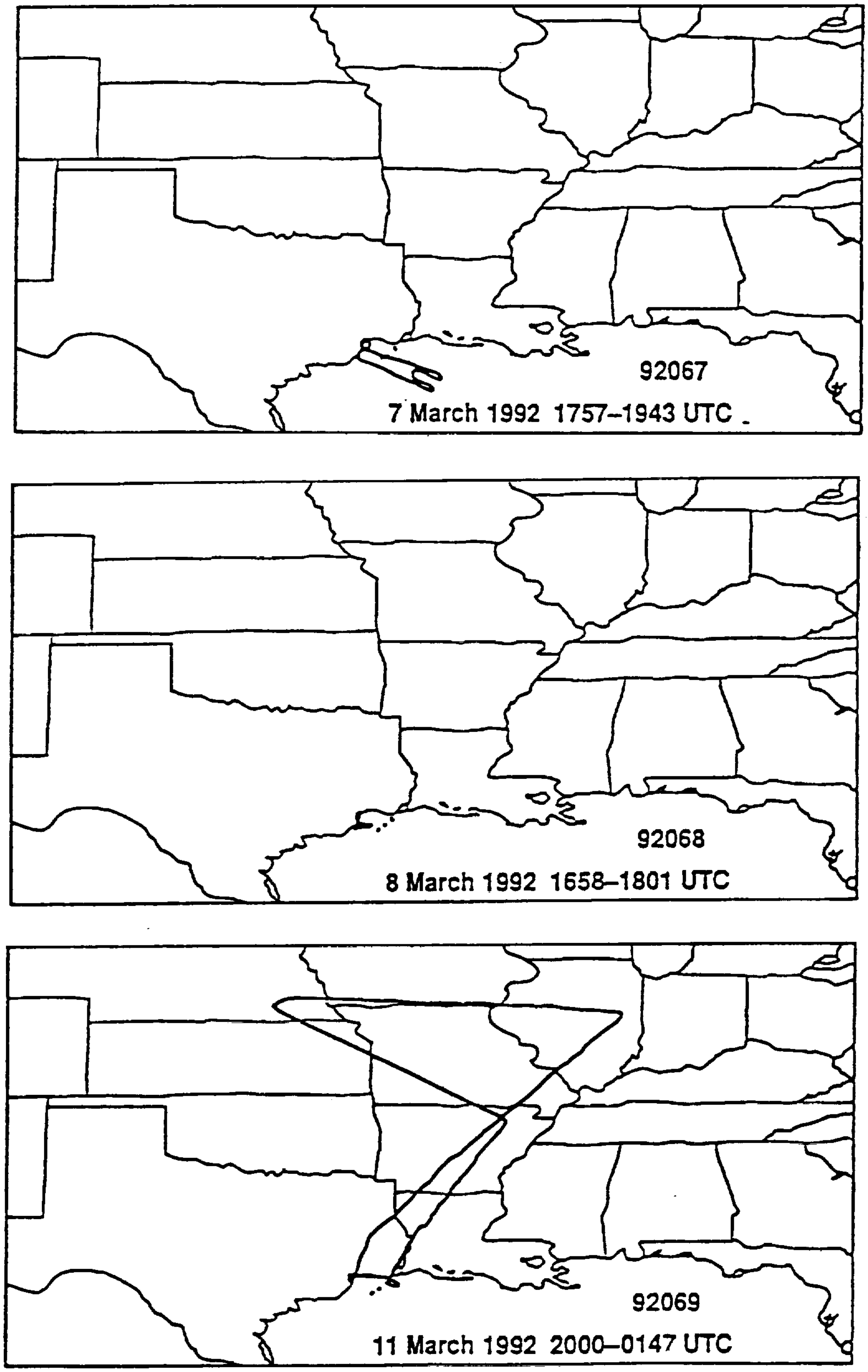

Figure 1. continued

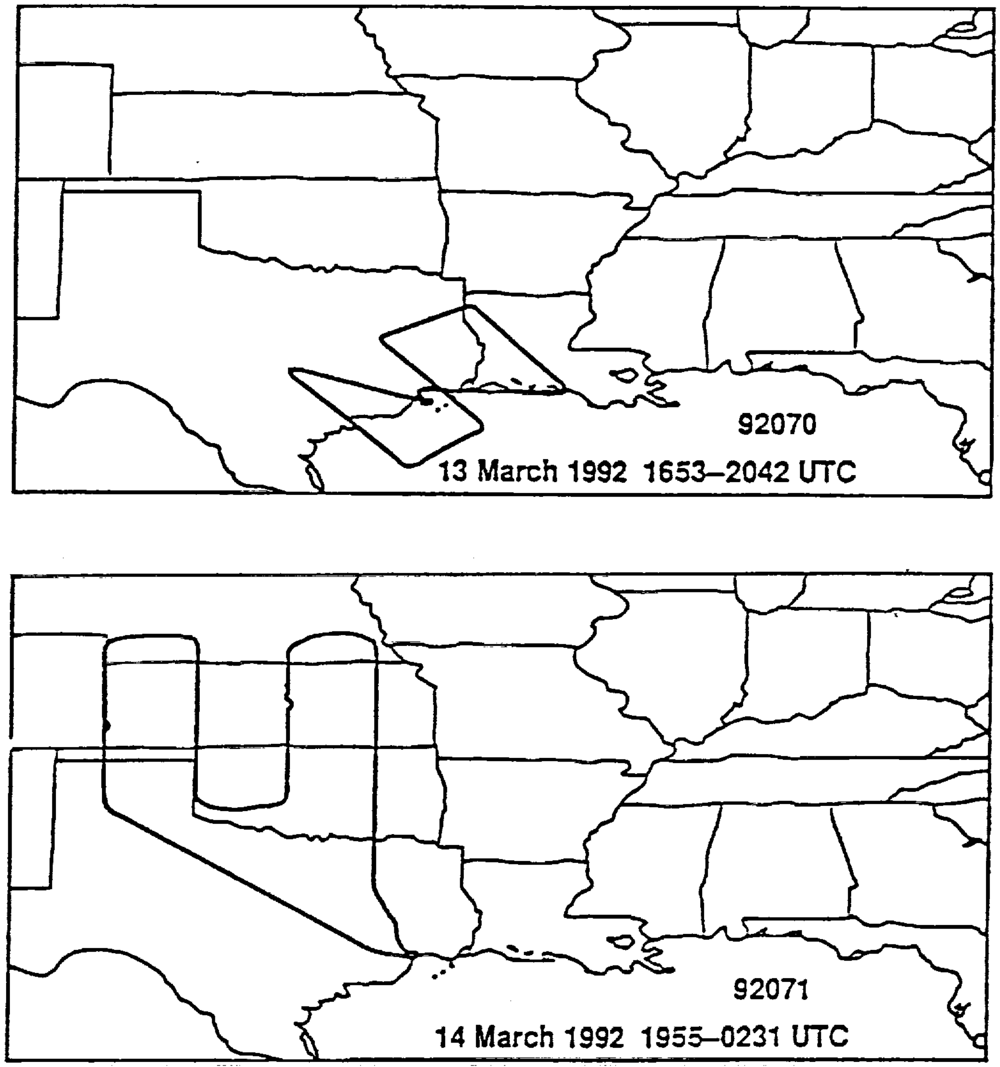

Figure 1. concluded

The sensitivity of each channel to variations in scene brightness temperature and dynamic range of the data is controlled by the channel gain and offset. For the Daedalus ER2 instruments these values must be preset. This is often a difficult task because instrument flight temperature often affects the performance of the electronics controlling these values. The expected dynamic range of the data is also often quite large which limits sensitivity of the 8 bit Daedalus data. Although 10 bit analog-to-digital boards are used, the current Daedalus data stream does not permit the storage of these 10 bit data in a conventional fashion. For the STORMFEST flights, the last four infrared channels of both the Wildfire and MAMS instruments where obtained and recorded at 10 bit resolution by using the MAMS "re-router" board (Jedlovec *et al.,* 1989). This printed wiring board effectively re-routes the least significant bits (lsb's, bits 9 and 10) of channels 9 - 12 to the channel 1 data stream. These lsb's are recombined with their 8 bit counterparts in post processing to create 10 bit data. The collection and reconstruction of the 10 bit data allows for an effective four-fold increase in channel sensitivity (over 8 bit data) in selected infrared channels without sacrificing dynamic range (a gain/offset change). Thus the gains can be set to cover a large dynamic range and still have the required sensitivity in the last four infrared channels. The sensitivity values reported in Tables 4 and 6 below represent the number of raw count values recorded for a given scene temperature change of 1 K (using 8 bit data for channel 8, and 10 bit data for channels 9-12). Infrared channel sensitivity is non-linear in temperature and decreases with decreasing scene temperature.

The determination of single sample noise (or NEΔT) in observed imagery can be calculated two ways. First, the single sample noise can be estimated with the use of structure functions (Hillger and Vonder Haar, 1988; Jedlovec, 1987; Hillger and Vonder Haar, 1979). This approach has a wide application since it does not require a perfectly uniform scene. Second, the variance can be computed directly over a uniform scene to estimate the single sample noise in the radiance data. In the later case, a uniform scene (such as a large water body for the thermal channels) is usually required. Therefore, the computed variance is directly related to the channel noise. A comparison of both approaches which showing the consistency of each method is presented by Jedlovec *et al.* (1989). The structure function method has been used with STORMFEST data because of its more general application to a variety of scene data, and its results are presented below.

1. Wildfire Flights: STORMFEST 1-5

The visible and infrared data for these flights are of good quality. Of primary importance is the quality of the infrared channels because of their use in deriving atmospheric parameters. Table 4 presents the 10 bit infrared channel sensitivities (in terms of counts per Kelvin) and dynamic range for the middle portion of each Wildfire flight. The infrared channel gains drifted during each flight making the channels more sensitive as the flight went on. The sensitivity change during each flight caused a limited dynamic range in channel 10 toward the end of the first flight (February 14); however, because of the cold temperatures during that day, channel saturation did not occur. Although this problem could not be corrected, the initial infrared channel gain settings were reduced during flights 2-5 to compensate for their drift. Sensitivity values changed for the first two flights during the gain adjustment period. By the last two Wildfire flights, a large dynamic range was achieved in the infrared channels without compromising channel sensitivity. Based on an analysis of the 10 bit data in channels 9-12 for the expected scene temperature range of 250-300 K, adequate thermal resolution and therefore sensitivity to scene temperature variations is available for quantitative analysis and product generation.

Single sample noise estimates were made using structure function analysis for all flights. In most cases lakes and reservoirs observed in the data under cloud free skies were used for the calculations. The results are presented in Table 5. Channel noise is a function of both instrument precision and the quantization level. As a result of the 10 bit data, the channel sensitivity is greater than the channel noise; therefore, a realistic single sample noise estimate can be obtained. Wildfire single sample noise values are typically less than 0.15 K for channels 8-10 and slightly greater for channel 11. The noise in channel 12 is considerably larger than the other infrared channels because of the poor responsivity of the optics in the longest wavelength channel. Channel 12 values range between 0.48 and 0.71 Kelvin for the five flights.

Noise in the calibration data can also be a problem in the use of the data. This noise manifests itself in the image data as line-to-line variations. The amplitude of these variations depends on the amplitude of the noise and the specific scene temperature. Jedlovec *et al.* (1986a, 1989) have shown for other Daedalus scanners that this noise is not always random but can be quite coherent. Attempts to reduce the effects of this calibration noise through temporal filtering of the data have been marginally successful. The effect of calibration noise in the Wildfire is not negligible and at times is quite significant. The noise is not confined to a particular infrared channel but is most prevalent in channel 12 (as expected from the single sample noise estimates presented above). The effect of this noise on the scene data can be quantified with structure function analysis by comparing the along- track and cross-track structure results. Since the calibration induced variations are only scan line dependent (separate calibration values are used for each scan line), the calibration-induced noise should only appear in the along-track structure values. An analysis of the structure results (not shown) bears this out. For the Wildfire channel 12 data of 14 February, the isotropic structure function value for a 50 m separation distance is 4 times greater in the along-track direction (1.37 square K) when compared to the across direction (0.36 square K). This indicates that a significant amount of the single sample noise estimated with isotropic structure functions (presented in Table 5) contains calibration induced error. The proportion of calibration noise in channels 8-11 is similar to that of channel 12. Thus, appropriate filter of the calibration data can further reduce the noise in the scene data for all channels.

2. MAMS Flights: STORMFEST 6-11

The MAMS visible and infrared data for these flights are of very good quality. Of primary importance is the quality of the infrared channels because of their use in deriving atmospheric water vapor parameters. Table 6 presents the 10 bit infrared channel sensitivities and dynamic range as before. While the new Daedalus scanner was used with the MAMS spectometer, the infrared channel gain drift was not as severe as with the Wildfire spectrometer. However, gain adjustments were necessary for the first few flights to establish the appropriate dynamic range of each channel. Sensitivity values changed in accordance to with the gain changes. Based on an analysis of the 10 bit data in channels 9-12, very high channel sensitivity was obtained with an adequate dynamic range. An improper resistor on the channel 11 gain setting prevented the measurement of channel 11 values below about 230 K, however.

Single sample noise estimates were made using structure function analysis for all flights. In most cases lakes, reservoirs, and open ocean scenes were observed in the data under cloud free skies and used for the calculations. The results are presented in Table 7. The single sample noise is extremely low for all of the infrared channels. This is consistent with previous flights in which the 5.0 mRa aperture was used. Line-to-line calibration variations are insignificant in the MAMS data sets.

C. Data Availability

Both the MAMS and Wildfire (MAS) instruments have very high data rates which exceed 200 megabytes of data per hour. These data is currently recorded on high density 14 track magnetic tapes during the flight. These 14 track tapes are permanently archived at NASA's Ames Research Center at Moffett Field, California. Limited amounts of MAMS and Wildfire data were processed in the field after each flight using the MSFC Quick View System (Jedlovec *et al.*, 1991). The QVS allowed for the rapid display and evaluation of Daedalus scanner data immediately after a flight. This evaluation served as the basis for gain changes from one flight to the next. All MAMS and Wildfire data collected during STORMFEST can be obtained from Ames in raw form (uncalibrated - level 0 data) on 9 track tape. The focal point for requesting these data is:

Jeff Myers (415-694-6252)
High Altitude Missions Branch
NASA Ames Research Center
Mail Stop 240-6
Moffett Field, CA 94035

MSFC has obtained all of the MAMS and Wildfire data for STORMFEST from Ames. Because of the volume of data and the number of data flights, these data will not be mass distributed or put in an active archive. Data for specific flights will be processed and made available on an individual request basis. Data can be requested in either raw or calibrated form on magnetic tape in either a McIDAS area data format or in a generic flat file format. Complete documentation of these formats will be provided upon request. For special case studies, higher level data may be available, including navigated and Earth located scenes and flight tracks. These scene data may be composed of either radiances or temperature data, and may include derived products such as integrated water and ozone content, upper level humidity, and cloud top temperatures. Scanner data and products produced at MSFC can be requested through:

Gary J. Jedlovec (205-544-5695)
Remote Sensing Branch
NASA Marshall Space Flight Center
Mail Code ES 43
Huntsville, AL 35812

TABLE 4. WILDFIRE INFRARED CHANNEL SENSITIVITY AND DYNAMIC RANGE FOR STORMFEST FLIGHTS 1-5. SENSITIVITY AND DYNAMIC RANGE VALUES ARE REPRESENTATIVE OF THE MIDDLE OF THE FLIGHT

Date	Channel	Wavelength (μm)	Sensitivity - 8/10 bit (cnts/K) Scene Temperatures (K) 225	250	275	300	Dynamic Range
Feb. 14							
	8	9.20	1.2	1.8	2.8	3.8	195 - 315
	9	10.00	5.7	8.0	11.2	14.8	195 - 315
	10	9.60	8.5	13.8	19.0	-	215 - 295
	11	10.95	5.4	8.0	10.8	13.3	195 - 320
	12	12.45	6.2	8.2	10.8	12.9	200 - 320
Feb. 17							
	8	9.20	1.0	1.7	2.5	3.3	0 - 315
	9	10.00	4.6	7.0	9.7	12.9	155 - 340
	10	9.60	2.5	4.2	6.1	8.2	0 - 315
	11	10.95	4.9	7.3	9.7	12.0	185 - 320
	12	12.45	5.4	7.4	9.5	11.4	200 - 320
Feb. 21							
	8	9.20	1.1	1.9	2.7	3.8	185 - 310
	9	10.00	5.2	8.0	11.4	14.8	200 - 315
	10	9.60	4.4	7.0	10.0	13.2	115 - 315
	11	10.95	5.6	8.0	10.8	12.9	200 - 315
	12	12.45	6.0	8.3	10.5	12.9	205 - 315
Feb. 23							
	8	9.20	1.1	1.9	2.8	3.7	180 - 310
	9	10.00	4.4	6.9	9.8	12.5	150 - 315
	10	9.60	4.8	7.7	11.1	14.8	190 - 310
	11	10.95	5.3	8.0	10.6	13.2	200 - 315
	12	12.45	6.0	8.0	10.5	12.5	205 - 320
Feb. 25							
	8	9.20	1.1	1.8	2.6	3.6	160 - 310
	9	10.00	4.2	6.6	9.1	11.8	120 - 315
	10	9.60	4.7	7.2	10.0	13.2	170 - 310
	11	10.95	5.1	7.4	9.8	12.5	195 - 315
	12	12.45	5.6	7.8	9.8	11.8	205 - 315

TABLE 5. SINGLE SAMPLE NOISE ESTIMATES FOR THE INFRARED CHANNELS FOR THE FIVE WILDFIRE FLIGHTS. SINGLE SAMPLE NOISE (NEΔT) USING 10 BIT DATA CALCULATIONS BASED ON EXTRAPOLATION OF SPATIAL STRUCTURE TO ZERO SEPARATION DISTANCE

Flight	Date	Channel	Wavelength (μm)	Scene Temperature (K)	NEΔT (K)
1	Feb. 14	8	9.20	273.5	<.25
		9	10.00	279.2	<.10
		10	9.60	268.9	<.10
		11	10.95	280.3	.13
		12	12.45	279.4	.53
2	Feb. 17	8	9.20	275.5	<.25
		9	10.00	282.9	.15
		10	9.60	270.0	<.15
		11	10.95	284.7	.13
		12	12.45	281.1	.54
3	Feb. 21	8	9.20	274.1	<.25
		9	10.00	282.1	.15
		10	9.60	268.4	.12
		11	10.95	283.1	.12
		12	12.45	280.0	.56
4	Feb. 23	8	9.20	280.6	<.25
		9	10.00	285.6	.13
		10	9.60	276.8	.11
		11	10.95	286.3	.15
		12	12.45	283.6	.71
5	Feb. 25	8	9.20	275.4	<.25
		9	10.00	283.7	.15
		10	9.60	269.4	.13
		11	10.95	285.6	.14
		12	12.45	283.2	.48

TABLE 6. MAMS INFRARED CHANNEL SENSITIVITY AND DYNAMIC RANGE FOR STORMFEST FLIGHTS 6 -11. SENSITIVITY AND DYNAMIC RANGE VALUES ARE REPRESENTATIVE OF THE MIDDLE OF THE FLIGHT

Date	Channel	Wavelength (μm)	Sensitivity - 8/10 bit (cnts/K) Scene Temperatures (K) 225	250	275	300	Dynamic Range
Mar. 1							
	9	6.5	5.2	11.1	20.0	-	0 - 280
	10	6.5	4.5	10.0	16.6	-	0 - 280
	11	11.1	7.6	11.1	14.2	-	195 - 290
	12	12.5	8.3	11.1	14.2	-	170 - 290
Mar. 7							
	9	6.5	3.3	7.1	12.5	-	0 - 295
	10	6.5	3.0	6.7	12.4	-	0 - 295
	11	11.1	-	11.1	14.3	16.7	230 - 305
	12	12.5	6.7	9.1	11.1	14.3	195 - 305
Mar. 8	Flight Aborted						
Mar. 11							
	9	6.5	3.3	7.1	12.5	-	0 - 295
	10	6.5	3.0	6.7	12.4	-	0 - 295
	11	11.1	-	11.1	14.3	16.7	230 - 305
	12	12.5	6.7	9.1	11.1	14.3	195 - 305
Mar. 13							
	9	6.5	3.3	7.1	12.5	-	0 - 280
	10	6.5	3.0	6.7	12.4	-	0 - 280
	11	11.1	-	11.1	14.3	16.7	230 - 305
	12	12.5	6.7	9.1	11.1	14.3	195 - 305
Mar. 14							
	9	6.5	3.3	7.1	12.5	-	0 - 295
	10	6.5	3.0	6.7	12.4	-	0 - 295
	11	11.1	-	11.1	14.3	16.7	230 - 305
	12	12.5	6.7	9.1	11.1	14.3	195 - 305

TABLE 7. SINGLE SAMPLE NOISE ESTIMATES FOR THE INFRARED CHANNELS FOR THE SIX MAMS FLIGHTS. SINGLE SAMPLE NOISE (NEΔT) CALCULATIONS BASED ON EXTRAPOLATION OF SPATIAL STRUCTURE TO ZERO SEPARATION DISTANCE

Flight	Date	Channel	Wavelength (μm)	Scene Temperature (K)	NEΔT (K)
6	Mar. 1	9	6.50	246.3	.14
		10	6.50	246.3	.14
		11	11.10	289.7	<.10
		12	12.50	286.8	<.10
7	Mar. 7	9	6.50	250.0	.13
		10	6.50	250.0	.13
		11	11.10	285.0	<.10
		12	12.50	281.3	<.10
8	Mar. 8	(flight aborted)			
9	Mar. 11	9	6.50	239.0	.12
		10	6.50	239.0	.12
		11	11.10	284.2	<.10
		12	12.50	280.7	<.10
10	Mar. 13	9	6.50	250.7	.12
		10	6.50	250.7	.11
		11	11.10	288.4	<.10
		12	12.50	284.4	<.10
11	Mar. 14	9	6.50	240.3	.14
		10	6.50	240.3	.14
		11	11.10	304.7	.10
		12	12.50	299.6	.10

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APPROVAL

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The information in this report has been reviewed for technical content. Review of any information concerning Department of Defense or nuclear energy activities or programs has been made the MSFC Security Classification Officer. This report, in its entirety, has been determined to be unclassified.

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